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Power generation and propulsion, electrical vehicles

04/02004 A thermodynamic study for the optimization of stable operation of free piston Stirling engines

Rogdakis, E. D. *et al. Energy Conversion and Management*, 2004, 45, (4), 575–593.

One of the most novel applications of the Stirling cycle is in the free piston configuration that was initially designed by W. Beale. In free piston Stirling engines (FPSEs), there are no mechanical linkages coupling the pistons or displacers, the motions of the reciprocating components follow the working gas pressure variations. Filippo de Monte and G. Benvenuto have recently proposed a linearization technique of the dynamic balance equations. The aim of this paper is to predict the thermodynamic conditions for stable operation of FPSEs and their modelling. The equations of the angular velocity are solved analytically in terms of the working gas mass and the displacer–piston phase angle of the machine. Using the criterion of stable engine cyclic steady operation, a mathematically rigorous form is obtained for the main parameters of the engine. Furthermore, for simplicity reasons, thermodynamic magnitudes are obtained using the Schmidt analysis (isothermal model).

04/02005 Development and validation of a comprehensive two-zone model for combustion and emissions formation in a DI diesel engine

Rakopoulos, C. D. *et al. International Journal of Energy Research*, 2003, 27, (14), 1221–1249.

A two-zone model for the calculation of the closed cycle of a direct injection (DI) diesel engine is presented. The cylinder contents are taken to comprise a non-burning zone of air and another homogeneous zone in which fuel is continuously supplied from the injector holes during injection and burned with entrained air from the air zone. The growth of the fuel spray zone, consisting of a number of fuel-air conical jets equal to the injector nozzle holes, is carefully modelled by incorporating jet mixing to determine the amount of oxygen available for combustion. Application of the mass, energy and state equations in each one of the two zones yields local temperatures and cylinder pressure histories. For calculating the concentration of constituents in the exhaust gases, a chemical equilibrium scheme is adopted for the C–H–O system of the 11 species considered, together with chemical rate equations for the calculation of nitric oxide (NO). A model for the evaluation of soot formation and oxidation rates is incorporated. A comparison is made between the theoretical results from the computer program implementing the analysis, with experimental results from a vast experimental investigation conducted on a fully automated test bed, direct injection, standard 'Hydra', diesel engine located at the authors' laboratory, with very good results, following a multi-parametric study of the constants incorporated in the various sub-models. Pressure indicator diagrams and plots of temperature, NO, soot density and of other interesting quantities are presented as a function of crank angle, for various loads and injection timings, elucidating the physical mechanisms governing combustion and pollutants formation.

04/02006 Development of empirically based burning rate sub-models for a natural gas engine

Soylu, S. and Van Gerpen, J. *Energy Conversion and Management*, 2004, 45, (4), 467–481.

Computer models of engine processes are valuable tools for predicting and analysing engine performance and allow exploration of many engine design alternatives in an inexpensive fashion. At the present work, experimentally based burning rate sub-models for flame initiation and propagation periods were developed for a natural gas engine. The sub-models do not require any knowledge of the flame shape and propagation speed to calculate the burning rate. The flame initiation sub-model determines where the flame propagation period starts so that experimental spark timing can be used for the calculations. The flame initiation and propagation sub-models were used along with a Zero Dimensional (Zero-D) model to calculate cylinder pressure traces for various engine operating conditions. The Zero-D model is able to match the measured pressure data with less than 8% error in magnitudes if the computations are started at the experimental spark timing. If the flame initiation sub-model is tuned for a specific engine operating condition, then the model is able to match the measured pressure with less than 1% error in magnitudes.

04/02007 Diesel engine exhaust gas recirculation – a review on advanced and novel concepts

Zheng, M. *et al. Energy Conversion and Management*, 2004, 45, (6), 883–900.

Exhaust gas recirculation (EGR) is effective to reduce nitrogen oxides (NO_x) from Diesel engines because it lowers the flame temperature and the oxygen concentration of the working fluid in the combustion chamber. However, as NO_x reduces, *particulate matter* (PM) increases, resulting from the lowered oxygen concentration. When EGR further increases, the engine operation reaches zones with higher instabilities, increased carbonaceous emissions and even power losses. In this research, the paths and limits to reduce NO_x emissions from Diesel engines are briefly reviewed, and the inevitable uses of EGR are highlighted. The impact of EGR on Diesel operations is analysed and a variety of ways to implement EGR are outlined. Thereafter, new concepts regarding EGR stream treatment and EGR hydrogen reforming are proposed.

04/02008 Diesel engine performance and emission characteristics using three-phase emulsions as fuel

Lin, C.-Y. and Wang, K.-H. *Fuel*, 2004, 83, (4–5), 537–545.

Diesel engines are employed as the major propulsion power source for both in-land and marine transportation primarily because of their simple, rigid structure and high fuel economy. It is expected that diesel engines will be widely used in the foreseeable future. However, the pollutants emitted from diesel engines, in particular nitrogen oxides and particulate matter, which are detrimental to the health of living beings and the ecological environment, have been recognized as a major air pollution source in metropolitan areas. This situation has attracted much research interest. Diesel oil emulsions have been used as one of many possible approaches to reduce diesel engine pollution. Previous relevant applications are been restricted to water-in-oil (W/O) two-phase emulsions. Three-phase emulsions, such as oil-in-water-in-oil (denoted as O/W/O) and water-in-oil-in-water (denoted as W/O/W), have not been used as alternative fuels for combustion equipment. The engine performance and emission characteristics using multi-phase O/W/O test fuels for diesel engines were investigated in this experimental study. The results show that using O/W/O or W/O emulsions resulted in lower exhaust gas temperatures and lower NO_x , CO emission and smoke opacity. The O/W/O emulsion appeared to produce higher exhaust gas temperatures but lower CO and NO_x emissions in comparison to W/O emulsions with the same added water proportion.

04/02009 Performance of single cylinder, direct injection Diesel engine using water fuel emulsions

Abu-Zaid, M. *Energy Conversion and Management*, 2004, 45, (5), 697–705.

A single cylinder Diesel engine study of water-in-Diesel emulsions was conducted to investigate the effect of water emulsification on the engine performance and gases exhaust temperature. Emulsified Diesel fuels of 0, 5, 10, 15 and 20 water/Diesel ratios by volume, were used in a single cylinder, direct injection Diesel engine, operating at 1200–3300 rpm. The results indicate that the addition of water in the form of emulsion improves combustion efficiency. The engine torque, power and brake thermal efficiency increase as the water percentage in the emulsion increases. The average increase in the brake thermal efficiency for 20% water emulsion is approximately 3.5% over the use of Diesel for the engine speed range studied. The proper brake specific fuel consumption and gases exhaust temperature decrease as the percentage of water in the emulsion increases.

04/02010 Research and development of new-fuel (DME-GTL) engine system

Gotto, S. *et al. Jidasha Gijutsu*, 2003, 57, (2), 77–84. (In Japanese) Recently, DME and GTL have attracted much attention as vehicle fuels. These fuels can be produced from natural gas, coal, and biomass. These are low-sulfur and low-aromatics alternative to diesel fuel. This paper presents a study on these fuels, including problems of their use in engine and their solutions.

04/02011 Technical, economic and environmental potential of cofiring of biomass in natural gas fired turbines and combined cycles

Zwart, R. *ECN-R [Report]*, 2003, 1–8.

Economic and environmental potential of co-firing of biomass and wastes in natural gas-fired power plants is discussed. Aspects evaluated include availability, contractability, and costs of biomass and waste for energy purposes; thermal conversion concepts used to co-fire biomass and waste in natural gas-fired turbines and combined cycles (CC); general economic and environmental potential of co-firing in natural gas-fired turbines and CC; economic and environmental potential of co-firing fuel gas in the RoCa₃ power plant of E.OO (electricity and supplier in Rotterdam); and governmental financial incentives for energy investments. Indirect gasification with advanced fuel gas